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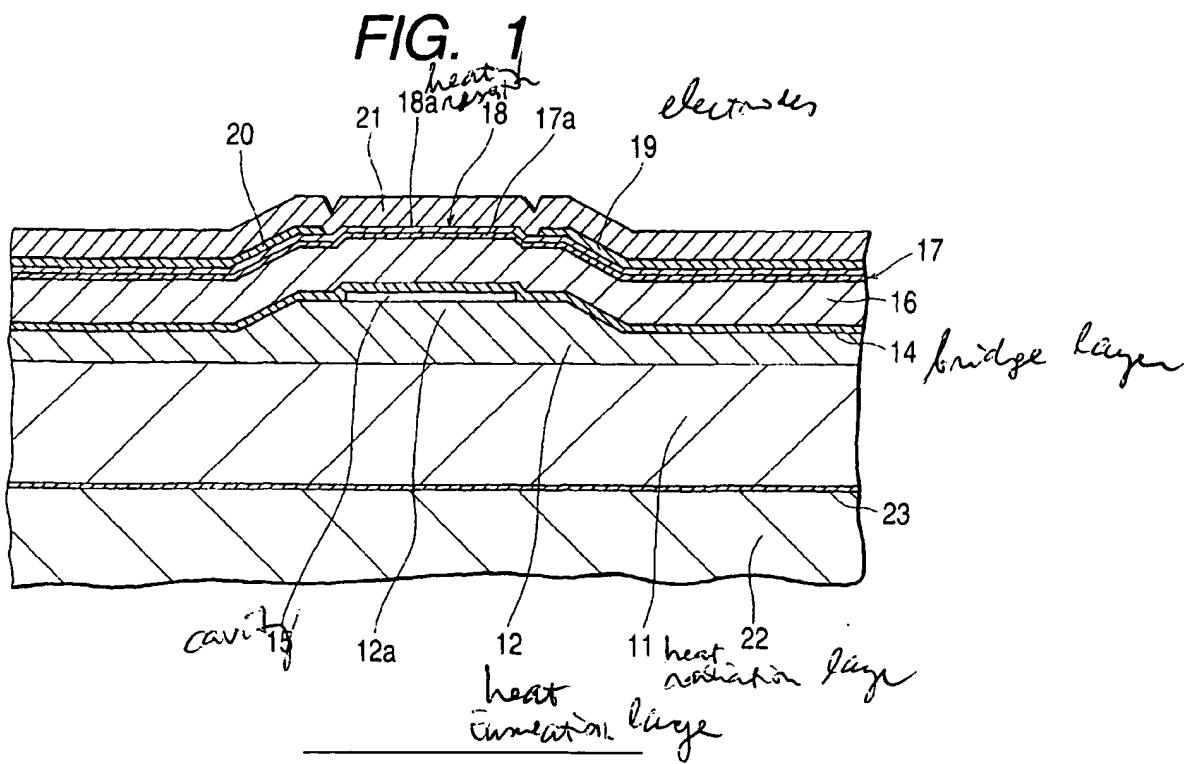
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(54) Thermal head enabling continuous printing without print quality deterioration

(57) In a thermal head according to the present invention, a sacrificial layer of transition metal is formed on a top surface of a heat radiation substrate (11); a bridge layer (14) of cermet or ceramic material is formed on a top surface of a heat insulation layer (12) including the sacrificial layer; a cavity (15) is made between the bridge layer and the heat insulation layer; a plurality of slits are made in the bridge layer overlying the cavity to

expose the cavity; a highly adiabatic inorganic heat insulation layer (16) is formed on a top surface of the bridge layer including the slits; and an inorganic protective layer (17) of a material selected from among silicon or aluminum oxide, nitride and carbide is formed on a top surface of the inorganic heat insulation layer, where heating elements are formed between the slits over the inorganic heat insulation layer and the inorganic protective layer.



Printed by Jouve, 75001 PARIS (FR)

Description**BACKGROUND OF THE INVENTION****1. Field of the Invention**

[0001] The present invention relates to a highly efficient thermal head which is used for a thermal printer.

2. Description of the Related Art

[0002] In a typical conventional thermal head, a glaze heat insulation layer 2 with a thickness of approximately 80 μm is wholly or partially formed on the end of a heat radiation substrate 1 made of alumina or similar material, as shown in Fig. 5.

[0003] A convex 2a with a height of approximately 5 μm is formed on the surface of this glaze heat insulation layer 2 by a photolithographic technique.

[0004] Also, heating resistors 3 made of Ta_2N , $\text{Ta}-\text{SiO}_2$, etc. are formed on the top surface of the glaze heat insulation layer 2 including the ridge-like convex 2a by sputtering and then the heating resistors 3 are processed so as to make up a pattern by a photolithographic technique.

[0005] Approximately 2- μm -thick electrodes for supplying an electrical energy to the heating resistors 3 are formed on the top surfaces of the heating resistors 3 by sputtering with Al , Cu , Au , etc.

[0006] Then the electrodes are etched by a photolithographic technique to make common electrodes 4 and individual electrodes 5 and external connection terminals (not shown) for the electrodes 4 and 5.

[0007] In order to protect the heating resistors 3 and electrodes 4 and 5 against oxidation and abrasion, an abrasion-resistant layer 6 of hard ceramic such as $\text{Si}-\text{O}-\text{N}$ or $\text{Si}-\text{Al}-\text{O}-\text{N}$ which is resistant to oxidation and abrasion is coated with a thickness of 5 to 10 μm over the heating resistors 3 and electrodes 4 and 5 by sputtering or a similar technique; thus durability in printing is ensured.

[0008] This conventional thermal head laminate is bonded to a heat sink 7 composed of an aluminum member, etc. using a resin adhesive 8 in a manner that the heat which is accumulated on the heat radiation substrate 1 during printing may be radiated to the outside; this finished thermal head is mounted into a thermal printer or the like.

[0009] In this type of conventional thermal head, Joule heat is generated on the heating resistors 3 to heat heat-sensitive paper or a thermal transfer ink ribbon (not shown) so that characters and images are printed by heat-sensitive paper coloring or ink transfer from the ink ribbon to recording paper such as plain paper.

[0010] The recent trend in thermal printers with a conventional thermal head as mentioned above is a compact, lightweight portable model capable of battery-powered operation.

[0011] In such a portable thermal printer capable of battery-powered operation, the element which consumes power most is a thermal head since it has a plurality of heating resistors 3.

5 [0012] For the purpose of power saving in a conventional thermal head, the glaze heat insulation layer 2 has been made thicker than before, in order to store more heat.

[0013] However, since this conventional thermal head 10 relies only on the approach of increasing the thickness of the glaze insulation layer 2, there may occur an excessive heat accumulation when the printer is run continuously; as a result, when it is used, for example, in a thermal transfer printer, ink from the ink ribbon may be transferred beyond the printing area, causing the phenomenon of trailing in printed image, or a poor print quality.

SUMMARY OF THE INVENTION

20 [0014] The present invention is made in view of the above problem and an object of the invention is to provide a thermal head which does not cause deterioration in print quality even in continuous printing or a similar condition and consumes less power than conventional models, and a manufacturing method therefor.

[0015] As a first solution to the above problem, the present invention provides a thermal head comprising: a heat insulation layer formed on a top surface of a heat 25 radiation substrate; a plurality of heating elements lined up on a top surface of the heat insulation layer; and an abrasion-resistant layer covering at least the top surfaces of the heating elements, wherein a sacrificial layer of transition metal is formed on a top surface of the heat radiation substrate; a bridge layer of cermet or ceramic material is formed on a top surface of the heat insulation layer including the sacrificial layer; a cavity is made between the bridge layer and the heat insulation layer; a plurality of slits are made in the bridge layer overlying 30 the cavity to expose the cavity; a highly adiabatic inorganic heat insulation layer is formed on a top surface of the bridge layer including the slits; and an inorganic protective layer of a material selected from among silicon or aluminum oxide, nitride and carbide is formed on a top surface of the inorganic heat insulation layer, the heating elements are formed between neighboring ones of the slits over the inorganic heat insulation layer and the inorganic protective layer.

[0016] Preferably, the heating elements are formed 35 on the inorganic protective layer's area projecting upward due to the cavity, and the thickness of electrodes is so designed that they are flush with or lower than the heating elements.

[0017] Preferably, the bridge layer is made of a cermet as a compound of a metal with a high melting point and SiO_2 or a ceramic such as SiO_2 , Si_3N_4 or $\text{Si}-\text{O}-\text{N}$.

[0018] Preferably, the inorganic heat insulation layer is made of a complex oxide or complex nitride as a com-

ound of silicon, transition metal and oxygen or nitrogen, and its thickness is from 5 μm to 20 μm and its thermal diffusivity from 0.3 mm^2/sec to 0.4 mm^2/sec .

[0019] Preferably, the inorganic protective layer is made of an insulating ceramic such as SiO_2 , SiC , Si-Al-O , Al_2O_3 or AlN with a thickness of 0.1 to 1 μm .

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The invention will be more particularly described with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view of the key part of a thermal head according to an embodiment of the present invention;

Fig. 2 is a sectional view of the key part of a thermal head according to another embodiment of the present invention;

Fig. 3A is a partially enlarged sectional view and Fig. 3B is a partially enlarged top view according to the present invention;

Fig. 4 is a graph showing resistance to foreign matters of a thermal head according to the present invention; and

Fig. 5 is a sectional view of the key part of a conventional thermal head.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Next, a thermal head according to the present invention and a manufacturing method therefor will be described referring to the accompanying drawings. Fig. 1 is a sectional view of the key part of a thermal head according to an embodiment of the present invention; Fig. 2 is a sectional view of the key part of a thermal head according to another embodiment of the present invention; Figs. 3A and 3B illustrate the method for making a cavity in a thermal head according to the present invention; and Fig. 4 is a graph which compares a thermal head according to the present invention with a conventional one in terms of thermal response.

[0022] As shown in Fig. 1, a 20- to 80- μm -thick heat insulation layer 12 of glass or heat-resistant resin such as polyimide resin is formed on the top surface of a heat radiation substrate 11 made of alumina or a similar material.

[0023] A convex 12a having a virtually trapezoidal cross section is formed on the surface of the heat insulation layer 12 in the form of a ridge whose height ranges from 5 to 10 μm .

[0024] A bridge layer 14 with a thickness of approximately 1 μm is formed on the top surface of the heat insulation layer 12 including the convex 12a, where the bridge layer is made of a cermet material for heating resistors 18 (stated later) such as TaSiO_2 or a ceramic material such as SiO_2 , Si_3N_4 or Si-O-N .

[0025] There is a cavity 15 with a height (clearance) of 0.1 to 2 μm on the top of the convex 12a between its surface and the bridge layer 14. As shown in Fig. 3, there are plural slits S spaced with a prescribed pitch in the area of the bridge layer 14 where this cavity 15 lies; the inside of the cavity 15 is exposed through the slits S.

[0026] Heating resistors 18a lie over each bridge area between slits S through an inorganic heat insulation layer 16 and an inorganic protective layer 17 (both stated later).

[0027] An inorganic heat insulation layer 16 of highly adiabatic and adhesive ceramic is formed on the top surface of the bridge layer 14 including the slits S.

[0028] This inorganic heat insulation layer 16 is a layer of highly adiabatic and adhesive ceramic with a thickness of 5 to 20 μm as a compound of Si, transition metal and oxygen and/or nitrogen.

[0029] In other words, the inorganic heat insulation layer 16 consists of a ceramic having one of the following combinations of ingredients: Si, a metal with a high melting point and oxygen; Si, a metal with a high melting point, and nitrogen; Si, a metal with a high melting point, and oxygen. Its thermal diffusivity is from 0.3 mm^2/sec to 0.4 mm^2/sec .

[0030] In addition, a highly adiabatic 0.1- to 1- μm -thick inorganic protective layer 17, made of such a material as SiO_2 , SiC , Si-Al-O , Al_2O_3 or AlN , is formed on the top surface of the inorganic heat insulation layer 16 in order to protect the inorganic heat insulation layer 16 electrically, chemically and mechanically. This inorganic protective layer 17 has a convex 17a which projects upwards due to the cavity 15.

[0031] On the top surface of the inorganic protective layer 17, there are heating resistors 18 made of a cermet consisting of Ta-SiO_2 and the like based on a metal with a high melting point. The heating resistors 18 consist of heating elements 18a lined up like dots on the convex 17a of the inorganic protective layer 17.

[0032] A 1- to 2- μm -thick layer of power supplying material containing Al, Cu, Au, etc. is formed at each side of the heating elements 18a; the layer at one side constitutes common electrodes 19 and the layer at the other side constitutes individual electrodes 20 and the heating elements 18a are sandwiched between these electrodes.

[0033] The electrodes 19 and 20 are as high as or lower than the heating elements 18a.

[0034] The heating elements 18a lie between slits S, over the inorganic heat insulation layer 16 and the inorganic protective layer 17.

[0035] An abrasion-resistant layer 21 of Si-O-N , Si-Al-O-N or the like with a thickness of approximately 5 μm covers the top surfaces of the heating resistors 18 and the electrodes 19 and 20.

[0036] According to the present invention, the laminate as described above is bonded to a metal heat sink 22 using an adhesive agent 23 and then the thermal head thus finished is mounted in a printer such as a bat-

terry-powered photo printer or portable mobile printer.

[0037] According to another embodiment of the present invention, as shown in Fig. 2, a heat radiation substrate 11 is made of silicon or metal; a ridge-like convex 11a is integrally formed on the surface of the heat radiation substrate 11 by a photolithographic or press technique and a bridge layer 14 is formed directly on the heat radiation substrate 11.

[0038] The thermal response characteristic of a thermal head according to the present invention will be explained referring to Fig. 4. The vertical axis represents change in heating element temperature when the thermal head is energized while the horizontal axis represents the duration of energization. F represents the time when the power is turned off.

[0039] Graph D shows the thermal response characteristic of a conventional thermal head and graph E shows that of a thermal head according to the present invention.

[0040] As illustrated by graph E and graph D in the figure, as a certain level of electric power is supplied to the conventional thermal head and the thermal head according to the present invention, the temperature of the heating elements 18a of the thermal head according to the present invention, which has a cavity 15, rises more quickly and are higher than that of the conventional thermal head, which has no cavity.

[0041] When the power to the thermal head is turned off at time F, or after a prescribed duration of energization, the temperature of the thermal head according to the invention (expressed by E) decreases more gradually than that of the conventional one (expressed by D), because E is higher than D during energization.

[0042] In such a thermal head according to the present invention, the highly adiabatic cavity 15 lies under the heating elements 18a with the inorganic heat insulation layer 16 and the inorganic protective layer 17 lying in-between so that thermal diffusion from the heating resistors 18 to the heat radiation substrate 11 is considerably reduced and a high heat accumulation efficiency is assured.

[0043] When the accumulated heat exceeds a certain temperature, it can be efficiently radiated toward the heat radiation substrate 11.

[0044] Therefore, the heating elements 18a can be heated in a shorter time to a temperature at which printing becomes possible and even in continuous printing, the heat accumulated in the inorganic heat insulation layer 16 and the heat insulation layer 12 can be efficiently radiated.

[0045] In addition, the thermal head according to the present invention requires less electrical energy to be supplied to the heating resistors 18 to heat the heating elements 18a to a temperature at which printing becomes possible, than the conventional thermal head.

[0046] In short, the thermal head according to the present invention increases the thermal efficiency and consumes less power, contributing to power saving in

portable thermal printers and similar printers.

[0047] The method for manufacturing such a high efficiency thermal head will be explained next focusing on the cavity 15. First, in the chamber (vacuum atmosphere) of a vacuum evaporator (not shown), a selectively etchable sacrificial layer 13 is formed on the convex 12a of the heat insulation layer 12 of glaze or polyimide resin, like a belt as shown in Fig. 3B.

[0048] Then, as shown in Fig. 3A, a bridge layer 14 is formed on the top surface of the heat insulation layer 12 including the sacrificial layer 13 and plural slits S which are shaped as desired and spaced with a prescribed pitch are made in the bridge layer 14 lying over the sacrificial layer 13 by a photolithographic technique in a manner that the underlying sacrificial layer 13 is exposed through these slits S.

[0049] Heating elements 18a are formed above each area of the bridge layer 14 between neighboring slits S by the intermediation of the inorganic heat insulation layer 16 and the inorganic protective layer 17 which lie in-between.

[0050] Next, the sacrificial layer 13 is dissolved and removed by pouring a selective etchant through the slits S. As a consequence, a cavity 15 as shown in Fig. 1 is formed between the bridge layer 14 and the surface of the convex 12a of the heat insulating layer 12 on which the sacrificial layer 13 lies.

[0051] Then, a highly adiabatic and adhesive inorganic heat insulation layer 16, made of a complex oxide or nitride, is formed on the bridge layer 14 including the slits S.

[0052] The inorganic heat insulation layer 16 turns into a low density black film with an insufficient level of oxygen or nitrogen through the process of reactive sputtering with high gas pressure; the resulting thermal diffusivity is from 0.3 mm²/sec to 0.4 mm²/sec. Therefore, in addition to its excellent heat insulation, it is highly adhesive since it contains free, active transition metal.

[0053] Thanks to the 5 to 20 μm thick inorganic heat insulation layer 16, the thermal head provides a sufficient mechanical strength to withstand repeated shearing stress applied to the heating elements 18a during printing, despite the presence of the underlying cavity 15.

[0054] Next, an inorganic protective layer 17 is laid over the inorganic heat insulation layer 16 to protect it; heating resistors 18 made of cermet with a high melting point are made on the inorganic protective layer 17.

[0055] The heating resistors 18 are annealed at a temperature not lower than 400 °C for stabilization. Electrodes, which include common electrodes 19 and an individual electrodes 20, are formed on the top surfaces of the heating resistors 18. Heating elements 18a are lined up like dots on the projecting area of the heating resistors 18 just above the cavity 15, between the common and individual electrodes 19 and 20.

[0056] The thickness of the electrodes 19 and 20 is so designed that they are flush with or lower than the

heating elements 18a.

[0057] Last, an abrasion-resistant layer 21 is laid over the heating resistors 18, common electrodes 19 and individual electrodes 20 to cover them; a thermal head is thus finished by a manufacturing method according to the present invention.

[0058] In a thermal head according to the present invention, an inorganic protective layer made of a material chosen from among silicon or aluminum oxide, nitride and carbide is laid over the top surface of an inorganic heat insulation layer and heating elements are formed on the inorganic protective layer, between slits made through the inorganic heat insulation layer and inorganic protective layer to expose a cavity. Consequently, thermal diffusion from the heating elements to the heat radiation substrate is considerably reduced and the thermal head can accumulate heat efficiently to keep a temperature suitable for printing.

[0059] Also, in continuous printing, accumulated heat can be properly radiated so that the problem of excessive heat accumulation can be avoided.

[0060] Since the heating elements lie between slits over the inorganic heat insulation layer and the inorganic protective layer, the stress applied to the heating elements during printing can be absorbed by the inorganic layers between slits; therefore, a thermal head with a high thermal efficiency and a high mechanical strength can be provided.

[0061] The heating elements are formed on the bridge layer's area projecting upwards due to the cavity, between the individual and common electrodes facing each other, and the thickness of the electrodes is so designed that they are flush with or lower than the heating elements. This reduces the stress applied to the electrodes during printing.

[0062] For this reason, a longer service life of the electrodes is assured though they are made of a relatively soft material.

[0063] The bridge layer is made of a cermet as a compound of a metal with a high melting point and SiO_2 or a ceramic such as SiO_2 , Si_3N_4 or Si-O-N so it can be made to adhere firmly to the glass heat insulation layer and inorganic heat insulation layer. This helps lengthen the service life of the thermal head.

[0064] The inorganic heat insulation layer is made of a complex oxide or complex nitride and its thickness is from 5 μm to 20 μm and its thermal diffusivity from 0.3 mm^2/sec to 0.4 mm^2/sec , so the thermal head provides both a high thermal efficiency and a longer service life.

[0065] The inorganic protective layer is made of an insulating ceramic such as SiO_2 , SiC , Si-Al-O , Al_2O_3 or AlN and has a thickness of 0.1 to 1 μm , so chemical resistance, stress resistance, diffusion resistance and non-conductivity are maintained during the photolithographic process or heat treatment for the heating resistors.

[0066] Accordingly, the heating resistors can be made with high accuracy by a photolithographic technique so

that fluctuations in the resistance value of the heating resistors can be minimized.

[0067] In the manufacturing method for a thermal head according to the present invention, an inorganic protective layer is laid over an inorganic heat insulation layer and the heating resistors and the electrodes are formed on the inorganic protective layer, so a thermal head with a high thermal efficiency and a high durability can be produced at a lower cost.

[0068] This manufacturing method makes it possible to produce a power saving thermal head suitable for use in a mobile printer such as a battery-powered model.

[0069] The sacrificial layer uses either Al , Cu or Mo as its material and has a height of 0.1 to 2 μm , so it can be easily removed by a photolithographic technique in order to make a cavity, leading to an easier thermal head production process.

[0070] The inorganic heat insulation layer is formed on the top surface of the bridge layer including the slits by sputtering, which also contributes to an easier production process.

Claims

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1. A thermal head comprising:

30 a heat insulation layer formed on a top surface of a heat radiation substrate;
a plurality of heating elements lined up on a top surface of the heat insulation layer; and
an abrasion-resistant layer covering at least a top surfaces of the heating elements,

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wherein a sacrificial layer of transition metal is formed on a top surface of the heat radiation substrate,

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wherein a bridge layer of cermet or ceramic material is formed on a top surface of the heat insulation layer including the sacrificial layer,

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wherein a cavity is made between the bridge layer and the heat insulation layer,

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wherein a plurality of slits are made in the bridge layer overlying the cavity to expose the cavity,

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wherein a highly adiabatic inorganic heat insulation layer is formed on a top surface of the bridge layer including the slits,

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wherein an inorganic protective layer of a material selected from among silicon or aluminum oxide, nitride and carbide is formed on a top surface of the inorganic heat insulation layer, and

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wherein the heating elements are formed between neighboring ones of the slits over the inorganic heat insulation layer and the inorganic protective layer.

2. The thermal head according to Claim 1, wherein the

heating elements are formed on the inorganic protective layer's area projecting upwards due to the cavity, and wherein the thickness of electrodes is so designed that they are flush with or lower than the heating elements. 5

3. The thermal head according to Claim 1, wherein the bridge layer is made of a cermet as a compound of a metal with a high melting point and SiO_2 or a ceramic such as SiO_2 , Si_3N_4 or Si-O-N . 10
4. The thermal head according to Claim 1, wherein the inorganic heat insulation layer is made of a complex oxide or complex nitride as a compound of silicon, transition metal and oxygen or nitrogen, and wherein its thickness is from $5 \mu\text{m}$ to $20 \mu\text{m}$ and its thermal diffusivity from $0.3 \text{ mm}^2/\text{sec}$ to $0.4 \text{ mm}^2/\text{sec}$ 15
5. The thermal head according to Claim 1, wherein the inorganic protective layer is made of an insulating ceramic such as SiO_2 , SiC , Si-Al-O , Al_2O_3 or AlN with a thickness of 0.1 to $1 \mu\text{m}$. 20

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FIG. 1

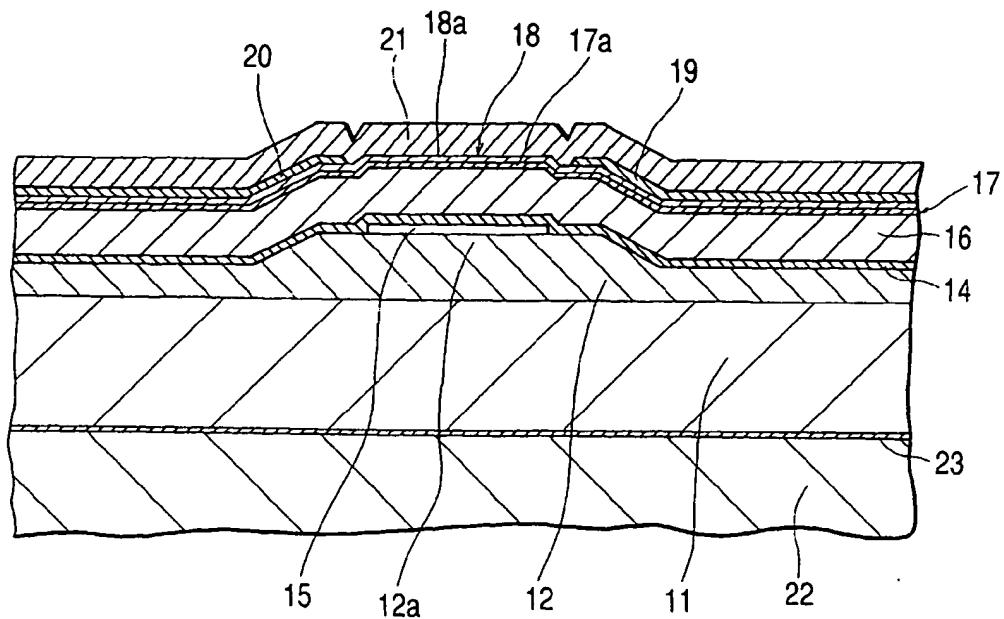


FIG. 2

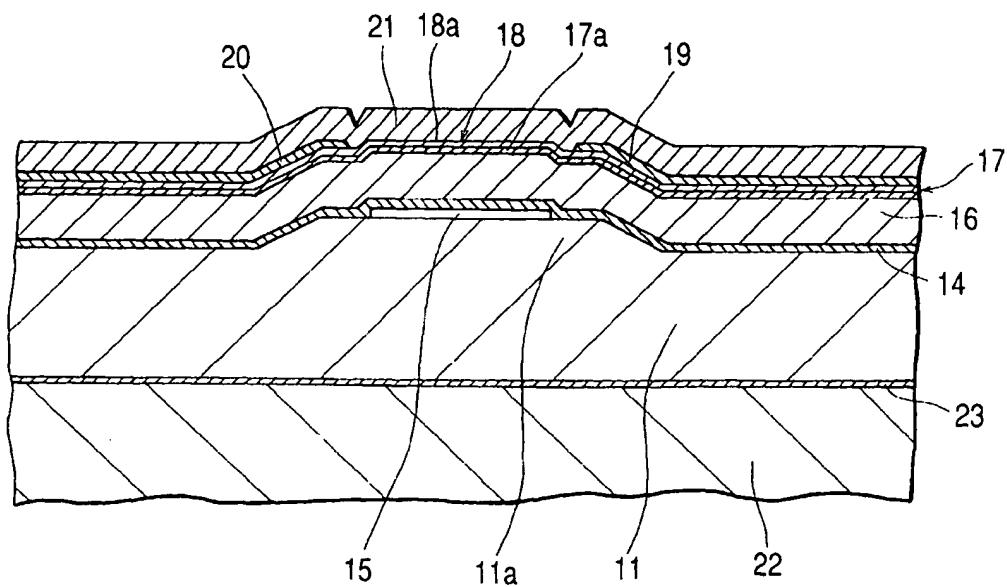


FIG. 3A

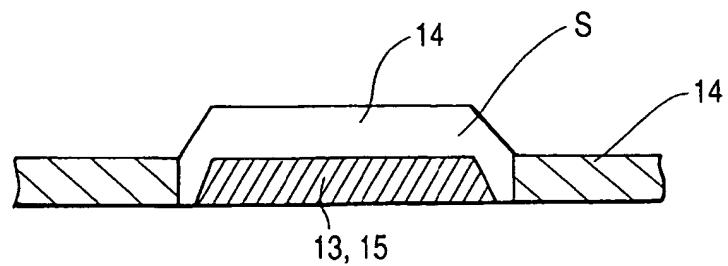


FIG. 3B

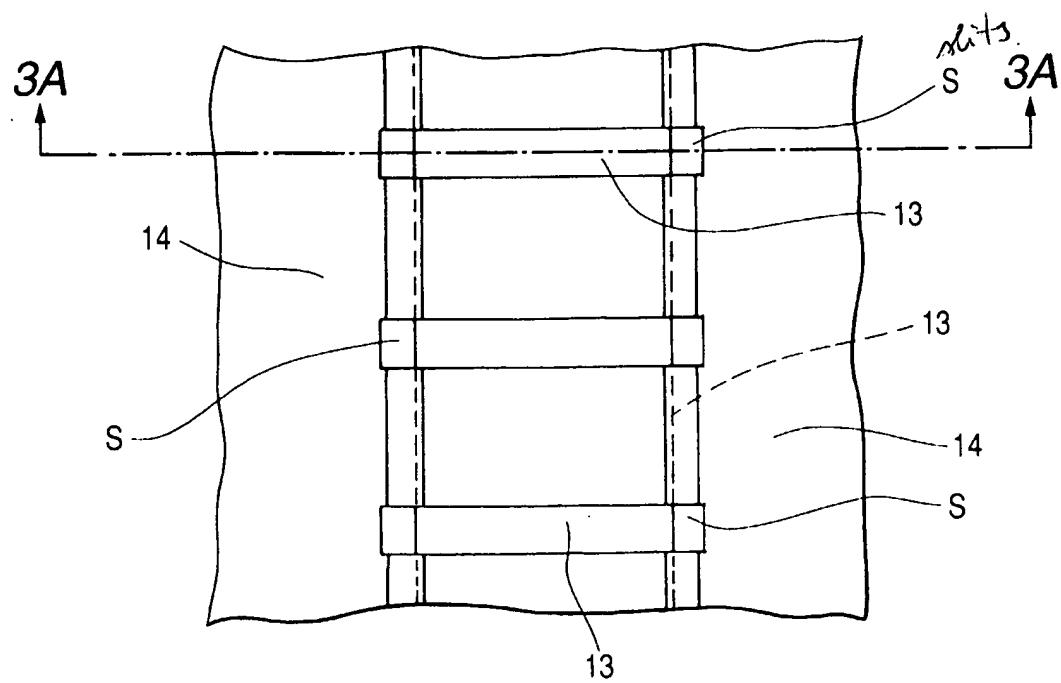


FIG. 4

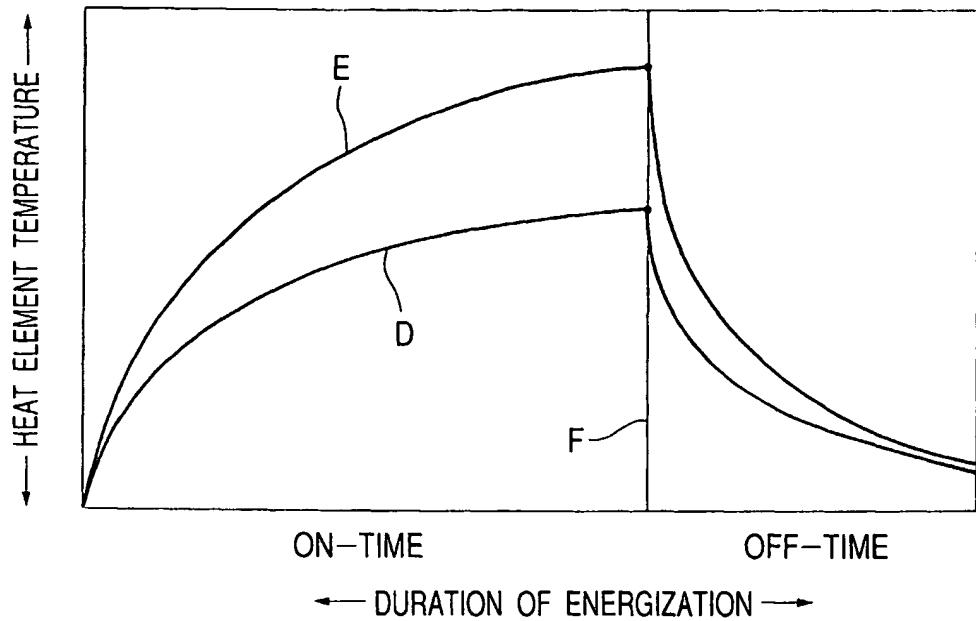


FIG. 5 PRIOR ART

